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AH-64 AAH CONCEPT FORMULATION SPECIFICATION

LR-859

The SINGER Company, Link Division

Binghamton, New York

September 1977

Prepared for:

NAVAL TRAINING EQUIPMENT CENTER

Orlando, Florida 32813

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NOTE: This draft dated 1 August 1977
has not been approved and is subject
to modification.
DO NOT USE FOR PROCUREMENT PURPOSE

TRAINER PERFORMANCE SPECIFICATION FOR DEVICE 2B40, AH-63/64 FLIGHT AND WEAPONS SIMULATOR

"This specification has been approved by the Naval Training Device Center, Department of the Navy."

1. SCOPE

1.1 This specification covers the requirement for the design and fabrication of Device 2B40, the Advanced Attack Helicopter (AAH) Flight and Weapons Simulator (FWS). The AAH is a twin-engine, rotary-wing aircraft designed to destroy or disrupt enemy armor and mechanized forces by aerial firepower. The training device will consist of a pilot trainer and a copilot-gunner (CPG) trainer. The trainer will be used for either pilot or CPG training, or used in an integrated mode for simultaneous pilot and CPG training. The trainer will include a trainee station, an instructor station, a motion system, a visual display, and a digital computation system with peripheral equipment.

2. APPLICABLE DOCUMENTS

2.1 The following documents of the issue in effect on the date of invitation for bid or request for proposal, form a part of this specification to the extent specified herein.

SPECIFICATIONS

Federal

L-P-383	Plastic Material, Polyester Resin, Glass Fiber Base, Low Pressure Laminated

Military

MIL-C-29025	Communication Systems for Training Devices, General Specification for

MIL-STD-1378	Requirements for Employing Standard Hardware Program Modules
MIL-STD-1389	Design Requirements for Standard Hardware Program Electronic Modules
MIL-T-23991	Training Devices, Military, General Specification for
MIL-P-25421	Plastic Materials, Glass Fiber Base Epoxy Resin, Low Pressure Laminated
MIL-R-9673	Radiation Limits, Microwave and X-Radiation Generated by Ground Electronics Equipment (as Related to Personnel Safety)

STANDARDS

Federal

FED-STD-595	Colors

Military

MIL-STD-461	Electromagnetic Interference Characteristics Requirements for Equipment.
MIL-STD-471	Maintainability Verification/ Demonstration/Evaluation
MIL-STD-781	Reliability Tests: Exponential Distribution
MIL-STD-1472	Human Engineering Design Criteria for Military Systems, Equipment, and Facilities
MIL-STD-143	Specifications and Standards; Order of Precedence for the Selection of
MIL-STD-749	Preparation and Submission of Data for Approval of Nonstandard Parts

PUBLICATIONS

Military

MIL-HDBK-217	Reliability Prediction of Electronic Equipment
MIL-HDBK-472	Maintainability Prediction

Department of the Navy

SECNAVINST 3560.1	Tactical Digital Systems Documentation Standards

Naval Training Equipment Center (NAVTRAEQUIPCEN)

Report 74-C-0039-A006	AH-1Q (Cobra) Helicopter Operational Flight Trainer Weapon System Simulator, Device 2B33, Configuration Report
NAVSO P-3097	Automatic Data Processing Glossary
Bulletin 301-2A	Parts, Nonstandard; Design Selection; Procedures for

Naval Ordinance Systems Command (NAVORDSYSCOM)

XWS 6788	Brayco 745

Department of the Army

AR 70-44 DoD Engineering for Transportability

(Copies of specifications, standards, publications, and drawings required by suppliers in connection with specific procurement functions shall be obtained from the procuring activity or as directed by the Procuring Contracting Officer).

2.2 Other publications - The following documents form a part of this specification to the extent specified. Unless otherwise indicated, the issue in effect on date of invitation for bid or request for proposal shall apply:

Federal Aviation Regulation (FAR)

AIM Part 1 COM-1-AGA-3 Airman Information Manual

United States Committee on Extension to the Standard Atmosphere

U.S. Standard Atmosphere, 1962

(Application for copies should be addressed to the Superintendent of Documents, Government Printing Office, Washington, DC 20402).

3. REQUIREMENTS

3.1 Materials, parts, and processes - Materials, parts, and processes shall be in accordance with MIL-T-23991 and as specified herein. Materials, parts, and processes used in the design of the digital computers and visual system assemblies shall conform to good commercial practices and standards. The design of the trainer shall be such as to limit the number of types and quantities of electromechanical and electronic parts which do not conform to Group I specifications as defined by MIL-STD-143. The contractor shall maintain a daily log of all parts meeting only the requirements of Group II, III, or IV specifications and drawings for inspection. An information copy of the updated portion of the daily log shall be immediately submi-ted to the Procureing Contracting Officer (PCO), Code N-2222, each time a part meeting the requirements of Group II, III, or IV specifications and drawings is added. Procedures for requesting specific waivers to use nonstandard items and the data requirements for obtaining approvals for these requests shall be as specified in MIL-T-23991 and MIL-STD-749. Procedures applicable to electronic type items are detailed in Bulletin 301-2A.

3.1.1 Plastics - Plastic material used to fabricate the cockpit shell shall be in accordance with L-P-383 or MIL-P-25421.

3.1.2 Standard electronic modules (SEM's) - Standard and predeveloped special SEM's will be considered as standard parts and no written approval to use will be required. New special SEM's that may be developed for this contract must comply with the requirements of MIL-STD-1378 and MIL-STD-1389. Deviations from MIL-STD-1378 must be approved by the Procuring Contracting Officer.

3.1.3 Microcircuits and semiconductor devices - Plastic encapsulated microcircuits and semiconductor devices shall not be used except where they are a part of commercial off-the-shelf equipment. Transistors, diodes, microcircuits, integrated circuits, and semiconductors encapsulated in the TO-92 plastic package shall not be used in any part of the trainer. Failure rates used in reliability predictions for plastic encapsulated microcircuits shall be four times the established failure rate for non-plastic microcircuits.

3.2 Design - Design shall be in accordance with MIL-T-23991 and as specified in 3.2.1 through 3.2.6 of this specification.

3.2.1 Design basis - The trainer shall provide training in aircraft control, cockpit preflight and starting procedures, normal and emergency procedures, navigational and instrument flight procedures, gunnery procedures and proficiency terrain flight, coordinated tactical mission, and shutdown and cockpit post flight procedures forthe AAH helicopter. Both instrument and visual flight training will be conducted. The design basis aircraft shall be the AAH helicopter production unit Number 1. The performance characteristics of the various modes of operation of the trainer shall reflect the characteristics of the operational aircraft within such tolerances as to result in fidelity of simulation necessary for the training of student pilots.

3.2.1.1 Strength - The trainer shall withstand, without damage, stresses incident to movement, handling in transit, hoisting, and tiedown aboard transporting vehicles, final installation, and use.

3.2.1.2 Housing - The trainer shall be designed for installation in permanent housing to be provided by the Government.

3.2.1.3 Cooling - Except as otherwise specified herein, trainer cooling shall be in accordance with MIL-T-23991. The trainer shall be designed to meet the climatic conditions of MIL-T-23991 by utilizing ambient room air to the maximum extent

possible. The use of supplementary air ducting shall be minimized. Temperature and air flow warning devices shall be mounted at equipment cabinet exhausts to sense potential "over temperature" conditions. The threshold level of sensing shall be adjustable.

3.2.1.4 Lighting - Trainer illumination shall be in accordance with Table XIX of MIL-STD-1472 and as specified herein.

3.2.1.4.1 Instructor station lighting - Illumination shall be provided at the instructor station to adequately illuminate all panels, displays, recorders, instruments, controls, and work surfaces. This lighting shall not provide glare or other distractions to the instructor or to the trainees. The lighting system shall not cue the trainees of instructor actions through shadows or flickering of lights.

3.2.1.4.2 Maintenance lighting - The existing utility power circuit shall be used to provide lighting in the trainee station area, under the trainer, and in any other normally dark or dimly lit areas where maintenance may be required. All bulbs shall be guarded from accidental breakage. Each group of lights shall be controlled by conveniently located ON/OFF switches. Reel-type extension cords may be utilized.

3.2.1.4.3 Emergency lighting - An emergency light set in accordance with MIL-T-23991 shall be provided.

3.2.1.5 Acoustical noise - The control of acoustical noise generation and penetration shall be in accordance with MIL-STD-1472. Except in the trainee station, where sound characteristics shall be in accordance with 3.6.1.9 of this specification, the acoustical noise level in operational areas of the trainer shall not exceed noise criteria of MIL-STD-1472.

3.2.1.6 Ash receptacles.- Ash receptacles of appropriate design shall be permanently installed at convenient locations throughout the trainer. There shall be at least one ash receptacle for each trainee position, one for each instructor position, and any other console or manned location. Ash receptacles shall be provided for observers adjacent to instructor consoles. Provisions shall be made for convenient removal of the contents of ash receptacles.

3.2.2 Mechanical design.- Mechanical design shall be in accordance with MIL-T-23991 and as specified herein and in 3.10.2.

3.2.2.1 Trainer construction.- Major components of the trainer shall be of modular construction such that installation, assembly, and disassembly can be accomplished without special equipment. Components shall be interconnectable by cable assemblies and hydraulic lines with easy disconnect connections

so that the trainer general arrangement and configuration may be changed with minimum effort. Means for leveling each major component shall be provided. Each major component shall have provisions for lifting and moving by forklift.

3.2.3 Electrical and electronic design.- Electrical and electronic design shall be in accordance with MIL-T-23991 and as specified in 3.10.2.

3.2.4 Optical systems.- Optical system design shall be in accordance with MIL-T-23991.

3.2.5 Human factors and training.- Design, selection, and arrangement of equipment shall be such as to insure ease, efficiency, and safety of operation in the performance of all necessary functions by instructional, maintenance, and trainee personnel in fulfilling the intended use of the trainer. Efficient and effective development of desired trainee skills and performance of all associated training functions shall be the primary consideration in all decisions affecting the design of the trainer and its component parts. In this regard, particular emphasis shall be placed upon design for training of the visual display and its interface with the trainee.

3.2.5.1 Human factors engineering.- The human factors engineering data and requirements of MIL-STD-1472 shall apply to the design of all work places and man-equipment interfaces. All aspects of trainer layout and configuration involving personnel access or use (except as may be required to simulate the configuration of the design basis aircraft) shall be governed by the dimensions of the human male using the 5th to 95th percentile range as a minimum standard.

3.3 Flight and Tactical Instructor Stations. - There will be a flight instructor station on the motion platform and a tactical instructor station in the computer area.

3.3.1 Flight Instructor Station. - The instructor station shall be housed to the rear of the trainee compartment. The instructor station shall include an adjustable seat mounted on rails that will allow the instructor to move from a position in front of the instructor station to a position so that monitoring of the trainee is optimized. The instructor station shall be provided with a console, which includes a multi-purpose CRT display system and controls and indicators necessary to monitor and control the training station and a visionics display monitor. The station shall be designed in accordance with MIL-STD-1472, and shall consist of the following:

(a) Program data display (CRT)

(b) Visionics (Visual) repeater

(c) Instructor station indicators and controls

(d) Intercommunications system

(e) Instructor seat

(f) Work surface

(g) Storage area.

3.3.1.1 Program data display (CRT). - A CRT display with operating keyboard(s) and adjustment controls shall be provided at the instructor stations. The data display system shall be designed in accordance with MIL-STD-1472 and shall have the following characteristics:

(a) Viewing area: The CRT shall have a rectangular data display area of no less than 180 square inches. Maximum use shall be made of the available CRT viewing area.

(b) Mounting: The CRT shall be ruggedized and shock mounted in such a manner that movement and vibration of the motion system shall not affect its legibility, accuracy, or reliability.

(c) Location: The CRT shall be positioned consistent with instructor use.

(d) Flicker: The phenomenon of flicker shall not be detectable. This requirement applies to any and all lines, points, letters, symbols, or other images displayed on the CRT.

(e) Symbol set size: Not less than 80 different symbols shall be included in the set available for display on the CRT.

(f) Symbol stability: Peak to peak short term drift, jittering or jumping of symbols, dots, and lines shall not be perceptible. The CRT traces shall not wander or deform. Drift shall not exceed 3/16 inch over an 8-hour period.

(g) Glare: The face plate of the CRT shall be designed to preclude glare.

(h) Symbol size: The physical size of the symbols shall be a function of the maximum viewing distance, resolution, contrast and brightness of the terminal.

3.3.1.1.1 Modes of operation.- The program data display system shall operate in three discrete modes; status mode, problem control mode, and communication mode. Changing between modes shall require less than one second.

3.3.1.1.1.1 Status mode.- Status mode for the CRT shall be used to present information to the instructor concerning the status of the simulated aircraft. This information shall be available as specified herein during training. The following display tableaus are required:

(a) Ground plots displaying traces of the flight path of the simulated aircraft through a portion of the problem world using instrument area landmarks (intersections, airfields, comm/nav facilities, approaches) or color terrain/tactical maps as necessary. The design requirement shall be to display up to not less than the most recent forty five (45) minutes of the flight path trace on the appropriate ground plot(s). Time index marks shall be placed at 5-minute intervals on the flight path. The areas represented by the plots shall have scales selectable for 8 x 8, 20 x 20 and 40 x 40 kilometers. Each ground plot display shall occupy a minimum of 144 square inches of the CRT display area. The display system shall have the capability of switching from scale to scale in either direction and retaining the continuity of the problem.

(b) A plot for displaying traces of altitude profile and aircraft track for GCA approaches. Upon activation of the automatic GCA control at the instructor station the CRT shall automatically display glide slope and azimuth plots with tolerance envelopes, superimposed on a one-mile grid network. The altitude profile and aircraft track shall be plotted on these plots.

3.3.1.1.1.2 Problem control.- In the problem control mode, the problem data display shall be used during training mode operation to monitor or modify initial conditions, establish or modify the training situation and to accomplish temporary (for the remainder of the training period) changes to the training situation or simulation parameters as well as to display the values of each. Problem control data display tableaus shall display for instructor implementation the following:

(a) Environmental conditions

(b) Weight and balance conditions

(c) Radio facilities

(d) Individual parameters of flight

(e) Initial condition parameters

(f) Aircraft system malfunctions

(g) Amount of on-board fuel

(h) Exercise listing and tolerances

(i) Emergency procedures

(j) Demonstration listing

(k) Current status of program variables (updated with time).

(l) Tactical training status and control

3.3.1.1.1.3 Communication mode.- In the communications mode, the following information shall be displayable on the CRT during training:

(a) Information concerning each simulated, programed ground radio/navigation facility within range in typical cross-country, approach and landing situations, or tactical missions.

(b) Clearance in effect

(c) Friendly force identifications and frequencies

3.3.1.1.1.4 Status, problem control, and communications modes.- The following information shall be displayed on the CRT during all three modes of 3.1.1.1.1

(a) Identification of any parameters of flight which are frozen.

(b) Indication that the simulated aircraft is in a freeze or initialization mode. This indication shall flash to indicate the aircraft has crashed or is initializing.

(c) Indication that a specified preprogramed or manually inserted malfunction (by name) will occur within 15 seconds (flash), for preprogramed malfunctions, or is in progress (steady).

(d) Indication of weapons status, including rounds remaining on board.

3.3.1.2 Visionics Repeater.- A CRT visionics repeater display with operating controls and adjustment controls shall be provided at the instructor stations. This repeater shall have the following characteristics:

(a) Viewing area: The CRT shall have a rectangular display area of not less than 180 square inches. Maximum use shall be made of the available CRT viewing area.

(b) Mounting: The CRT shall be ruggedized and shock mounted in such a manner that movement and vibration of the motion system shall not affect its legibility, accuracy, or reliability.

(c) Location: The CRT shall be positioned consistent with instructor use.

(d) Flicker: The phenomenon of flicker shall not be detectable. This requirement applies to any and all letters, symbols, or other images displayed on the CRT.

(e) Glare: The face plate of the CRT shall be designed to preclude glare.

(f) Symbol size: The relative size of the symbols shall correspond to those in the visionics displays.

3.3.1.2.1 Modes of Operation.- The visionics repeater CRT shall be capable of displaying any mode available to pilot or copilot at the scale selected in the cockpit.

3.3.1.3 Instructor station controls and indicators.- Keyset(s) and other controls and indicators shall be provided to enable the instructor to perform the functions associated with operation of the trainer and shall be located to facilitate utilization by the instructor. The following shall be provided:

(a) Controls for the operation of the CRT and visual repeater (e.g., focus, brightness, contrast)

(b) A keyboard to be used during the CRT communication, problem control, and status modes, for data retrieval, for the insertion or modification of data and to perform the CRT display control functions. Keyboard usage shall include the selection of information to be displayed during programing and communication CRT display mode operation. The keyboard shall be the primary means of communication, during training, between the instructors and the computer for the modification of training or simulation conditions within the limits specified herein. The functions of the keyboard and the limitations placed upon

its functions during training shall be determined by the computer program and shall not be modifiable from the keyboard itself.

(c) Controls to select CRT and visual repeater CRT display modes.

(d) Controls to permit selection of areas for display.

(e) Controls to reposition (reset) the simulated aircraft.

(f) Controls to vary the scale of the plots.

(g) Controls to erase the simulated aircraft track on the ground plot display. The erasure shall be progressive, beginning with the earliest portion of the track, such that the instructor can erase all or any portion of the track.

(h) Controls to reset the simulator and visual scene

(i) Controls to insert or remove any malfunction

(j) A control to freeze and unfreeze the device and indicate its status when in a freeze condition.

(k) Controls to communicate with trainees via intercom or through the simulated radio receivers. The instructor will use these controls, as appropriate, for didactic purposes and to provide voice simulation of all ground, airborne, and other voice transmitting stations.

(l) Controls to communicate via a maintenance intercom with personnel at the computer station and the tactical instructor station.

(m) A control to turn on and off the power to all equipment associated with the cockpit. The control shall indicate its ON/OFF status.

(n) A control to turn on and off the cockpit motion system. The control shall indicate the ON/OFF status of the motion platform. The status of each motion platform interlock also shall be indicated.

(o) A control to test for the proper functioning of all indicator lights.

(p) Controls for the adjustment of the intensity of instructor station lighting.

(q) A running time meter to indicate the total time that the instructor station and associated trainee station has been operated. The meter shall have at least five digits and shall record the time in increments of one-tenth of one hour.

(r) Controls to vary visual system parameters and introduce special effects.

(s) Controls to set a "Crash Override" condition allowing the simulator to continue flight through preset crash conditions.

3.3.1.4 Digital clock and timer. - The instructor station shall contain a digital clock which shall indicate the actual time of day. The digital clock shall show hours, minutes, and seconds. A problem time digital timer showing hours, minutes and seconds with start, stop and reset controls shall be provided at the instructor stations.

3.3.1.5 Headset/jacks. - Jacks with headsets for each instructor shall be provided at the instructor station positions. All jacks in the instructor and trainee stations shall be standard and shall accept both headsets and flight helmet connections.

3.3.1.6 Flight instructor seat. - An instructor seat shall be provided. Convenient-to-operate locking devices shall be provided for the swivel and the sliding track mechanisms. A seat belt shall be provided and attached to each seat. Twenty four inches of fore and aft adjustment shall be provided. A minimum up and down total adjustment of five inches shall be provided. Each seat shall be provided with fold-away arm rests, back cushion and seat cushion. The tactical instructor will use a chair designed to fit size requirements at the tactical instructor station.

3.3.1.7 Work surface. - Work surfaces shall be provided which can be used by the instructors for writing or placement of manuals and other data or material. It shall be located at a height convenient for writing while seated and shall extend an average of approximately eight inches in front of the instructor console.

3.3.1.8 Storage - Storage for securing stored material shall be provided inside the cockpit shell for the temporary storage of manuals, notebooks and similar reference material utilized by the instructor.

3.3.2 Tactical Instructor Station. - The instructor station shall meet the requirements of 3.3.1 above, except that the instructor shall have only indicators (instead of switches) for all functions not involved with his tactical control tasks, emergency controls, or tactical instructor display controls. The instructor shall have switches for control of tactical functions for which the flight instructor will have indicator lights.

3.3.3 Training programs. - The following training program shall be provided:

(a) Demonstration programs

(b) Check ride programs

(c) Exercise programs

(d) Automatic briefings

(e) Performance evaluation programs

(f) Performance recording and playback

3.3.3.1 Demonstration programs. - Automated demonstrations of flight, maneuvers and weapons delivery techniques, in accordance with flight training guides shall be provided. These demonstration programs shall be used in conjunction with the main trainer program. Upon activation of controls at the instructor station, the demonstration flight shall be executed such that the cockpit instruments, cockpit controls and the motion module exhibit the movements which would be experienced if the demonstration were actually being flown. Visual displays shall be synchronized. Pre-recorded verbal explanation and commentary shall be provided for each demonstration program and shall be played back in synchronization with the demonstration flight. The format and text of the demonstrations shall be subject to the approval of the Procuring Contracting Officer.

(a) Automated demonstration programs: The following maneuvers and weapons system exercises shall be presented in demonstration programs:

(1) Gunnery Exercises:

a. 69mm rocket delivery and harmonization (pilot and CPG)

b. 30mm delivery and harmonization (pilot and CPG)

c. Hellfire missile deivery and harmonization

d. NAP of the earth gunnery/and hovering fire

(2) Contact flight maneuvers:

a. Hovering maneuvers:

1. Takeoff to a hover

2. Forward hovering

3. Rearward hovering

4. Sideward hovering

5. Landing from a hover

6. Hovering turns

b. Approach maneuvers:

1. Normal to a hover angle 8° to 10°

2. Normal to the ground angle 8° to 10°

3. Steep to the ground angle 12° to 15°

4. Steep to a hover angle 12° to 15°

c. Takeoffs:

1. Normal from the ground and hover

2. Maximum performance

3. Running

d. Running landings

e. Simulated hydraulic failures to a running landing:

1. System #1

2. System #2

3. Dual systems

f. Autorotations:

1. Power recovery
2. Termination with power
3. Touch down
4. Low level flat - glide
5. Low level high speed flat glide
6. Autorotation with turn
7. From hover (at varying aircraft weights)

g. Force landings:

1. Normal 60 to 120 knots
2. On takeoffs
3. On approaches
4. High speed 120 knots to 190 knots
5. Hovering

h. Tail rotor failures:

1. Fix left
2. Fix right
3. Neutral
4. Loss of component of thrust

i. Dives:

1. Normal 12° to 15°
2. Steep 30° to 40°

j. Nap of the earth flight/navigation

(3) Tactics

a. Full tactics demonstrations

1. Basic tactics techniques
2. Threat engagement

b. Dummy demonstration (for tactics training) in these demonstrations, the entire tactical scene is dynamic and interactive. The crew will control the simulated aircraft within this environment.

3.3.3.1.1 Spare demonstration program formulation and capacity. - Capability shall be provided to construct automated demonstration programs using the performance recording and playback capabilities of 3.3.3.6. Spare computer memory (disk) shall be provided for an additional 50 minutes of demonstration programs.

3.3.3.2 Check ride programs. - Two automated Army flight performance checkride programs shall be provided:

(a) A contact visual checkride

(b) A tactical weapons delivery mission.

The visual checkride shall include: taxiing, takeoff to hover, hover, hovering takeoff, normal climb, cruise, enroute to stagefield, entry into traffic pattern at stagefield, normal approach and takeoff to and from ground, steep approach to ground, maximum performance takeoff from the ground, engine failure on final-requiring an autorotation, engine failure in hover, hovering maneuvers (turns, crosswind landings, and takeoffs), confined area landing and takeoff, with or without external loads, autorotation with power recovery, low level flat glide autorotation, low level high speed autorotation, running landing with simulated hydraulic malfunction, and running takeoff. The weapons delivery mission shall include aircraft startup, take off, approach to target or targets, nap of the earth (low level) approach, attack of designated targets with multiple weapons systems, harmonization of weapons and return to base. At least two aircraft malfunctions shall be introduced during the course of the mission. During the checkride mode of operation, the instructor shall be inhibited from activating controls at the instructor station which would have the effect of interrupting the checkride, changing the checkride characteristics, performance parameter being recorded, or tolerances.

3.3.3.2.1 Checkride data. - Concurrently with an automated checkride a hard-copy record shall be provided of the performance error measurement data of 3.3.3.5.1 which occurred during each maneuver segment of that checkride. The record shall be in English language, symbology.

3.3.3.3 Exercise programs. - The instructor shall have the capability of running as an automated training exercise, any major segment of either of the checkrides described in 3.3.3.2 All performance recording and data output provisions described in 3.3.3.2 and 3.3.3.5 shall apply. The individual

exercises shall be called up and enabled through the Instructor stations.

3.3.3.4 Automatic briefing. - Audio briefing tapes that describe the exercise or program shall accompany each exercise and checkride program. These briefings shall include a description of the content to be presented, the criteria of performance expected of the trainee, and any other information required to initiate the exercise.

3.3.3.5 Performance measurement. - A performance measurement capability shall be provided which, by comparing trainee performance with pre-programmed or inherent performance tolerances, automatically determines trainee errors. During checkride or exercise mode operation, the instructor shall enter data for the trainee on performance parameters for which no tolerances can be established (e.g., communications).

3.3.3.5.1 Performance error measurement. - During trainee and checkride mode operation, errors in trainee performance shall be recorded whenever his performance on a particular parameter differs from the performance which has been designated as ideal performance for that parameter, plus or minus the tolerance which also has been designated for it. Frequency of deviation and cumulative time out of tolerances shall be recorded automatically for the parameters specified for each maneuver. Specific parameters to be measured for each maneuver segment and parameter tolerances for that segment shall be determined by the contractor subject to approval of the Procuring Contracting Officer. The parameters shall be selected so as to avoid continuing to penalize the trainee for errors recorded in previous maneuvers for which there is no training value in the present maneuvers.

3.3.3.5.2 Performance parameters. - The performance parameters for which errors are to be recorded shall include the following:

(a) Airspeed

(b) Altitude

(c) Course deviation

(d) Glide slope deviation

(e) Rate of climb

(f) Rate of turn

(g) Pitch attitude

(h) Bank angle

(i) Torque

(j) Trim control

(k) Ball angle

(l) Rotor RPM

(m) Target to weapon impact-distance and position

(n) Automatic weapons firing burst duration

(o) Masking errors and duration

In addition to the above parameters, procedural error, e.g., proceeding below established minimums or failure to execute a heading change at an appropriate point, weapons delivery panel operation and operational errors i.e., exceeding published aircraft "red-line" parameters shall be recorded automatically.

3.3.3.5.3 Performance error recording. - Simultaneously with the sensing of an error, a symbol indicating the type of error shall be inserted along the flight path plot. Symbology and formats of error display shall be determined by the contractor, subject to the approval of the Procuring Contracting Officer.

3.3.3.6 Performance recording and playback. - A record on disc of the most recent 30 seconds of helicopter performance for the trainer module shall be retained. This recording shall be divided into 30 segments of one second each. These recorded segments shall be recallable by the Instructor in less than 30 seconds for presentation to the trainee as a demonstration in which the simulated aircraft repeats the recorded performance. A synchronized voice recording shall be provided which shall record and playback all of the communications and instructional messages transmitted or received by the trainee during the recorded flight segments. It shall be possible to freeze or to terminate a playback at any point.

3.3.3.7 Main trainer program variations. - The following additions to the main trainer program shall be provided to enable the instructor to vary the training situation.

3.3.3.7.1 Failures and malfunctions programs. - Programs shall be provided to simulate up to 100 gradual or abrupt failures or malfunctions of the helicopter systems or components for conditions to be determined. Failures, malfunctions, and emergency conditions (onset, incremental effects, duration, etc.) shall occur as in the helicopter. Initiation shall be via instructor station controls. Failures will remain in effect until corrective action is taken by the trainee or the failure is removed by the Instructor.

3.3.3.7.2 Initial condition sets. - The simulation program shall contain initial condition parameters for the simulated aircraft. At least ten preselected sets of initial conditions shall be provided and shall include altitude, velocity, heading, geographical location, gross weight, configuration, weapons loading, and engine and navigation instrument readings. The contents of these sets and their mechanization shall be subject to approval by the Procuring Contracting Officer. In addition, the instructor shall have the capability of selecting the initial conditions set of any checkride segment during non-automated training. The instructor shall have the capability of verifying existing initial conditions and modifying them through the Instructor station.

3.3.3.7.2.1 Zeroing mode. - A zeroing mode (subroutine) shall be included which, when activated by the instructor, shall return the simulation problem to a preselected initial condition. Selection of this function shall clear all memory locations of modified problem conditions and parameters in order that new problem initializing data can be introduced.

3.3.3.7.3 Problem freeze and restart provision. - It shall be possible for the instructor to freeze the total simulation problem at any time. The routine for freeze control shall permit displays, and other computer controlled outputs to retain all indications and system status conditions that existed at the time of freeze initiation. Deactivation of the freeze shall restore the system to the conditions that existed at the time of the freeze.

3.3.3.7.4 Parameter freeze. - During non-checkride training the instructor shall be able to freeze the following parameters, individually or in combination, from the instructor console.

(a) Attitude

(b) Altitude

(c) Velocity

(d) Heading.

Indications of parameters frozen shall be provided on the multi-purpose CRT display at the appropriate instructor station.

3.4 Visual Simulation System

3.4.1 General Visual System Requirements - The following requirements apply to both the out-the-window and visionics portions of the visual system.

3.4.1.1 Intended Use - The visual system shall provide all the visual cues and related visual system interfaces necessary to train experienced pilots to function as two-man teams in the operation of the AAH. Transition flight and battlefield operations training shall be provided under a wide variety of climatic, topographical, and tactical situations.

3.4.1.2 System Integration

3.4.1.2.1 Dynamic Response - The dynamic response of the visual system shall be sufficient to track that of the motion system without introducing any conflict between the cues provided by the visual and motion systems. In addition, the lag between any two cues will be no more than 50 ms, to be measured as the difference between the times to obtain 50% of final value. If the visual system design requires the pilot/co-pilot/gunner spacing in the simulator to be different from that in the aircraft, it shall not preclude the motion system from providing the proper motion cues to either the pilot or co-pilot/gunner as an instructor selection.

3.4.1.2.2 Configuration - That portion of the visual system mounted on the motion system shall be configured to facilitate ease of entrance to and egress from the cockpit, and shall not intrude into the cockpit area to the extent that the cockpit area would no longer provide a realistic environment. It shall meet all performance requirements with the normal operating range of the motion system, and shall withstand, without damage, the stresses imposed by a single failure within the motion system.

3.4.1.3 On-Board Systems - The visual system shall interact with the controls for the following systems and components to the extent necessary to accomplish the training objectives:

(a) Integrated Head And Display Sighting System
(b) Pilot Night Visual System
(c) Target Acquisition Designation System
(d) Video Recorder
(e) Laser Rangefinder
(f) Fire Control
(g) Symbol Generator
(h) Angle Measuring System, Pilot and Copilot/Gunner

The visual system shall provide imagery of those components of the aircraft structure and payload normally visible to the crew within the field of view of the visual system in a position and orientation which produces no conflict with the perception of these items in the actual aircraft. These items shall include, but not be limited to, aircraft structure, ordnance, and rotor.

3.4.1.4 Visual Training Tasks - Visual cues will be provided to train in the following tasks or maneuvers.

(a) Transition Training

1) Take off and landing to hover
2) Hover flight
3) Take off from hover
4) Take off from ground
5) Maximum performance takeoff
6) Running takeoff
7) Maximum load takeoff
8) Slope takeoff
9) Aborted takeoff
10) Climbout
11) Above ground effects hover
12) Normal traffic pattern
13) Normal cruise
14) Climbing turn
15) Descending turn
16) Acceleration/deceleration
17) Quick stop
18) Straight climb
19) Straight descent
20) Level turns
21) Normal approach to ground
22) Normal approach to hover
23) Shallow approach
24) Steep approach
25) Slope landing
26) Autorotation to touchdown
27) Autorotation - terminate with power
28) Autorotation - power recovery
29) Hovering autorotation
30) Low-level autorotation
31) Low-level high speed autorotation
32) Turning autorotation
33) Minimum ground run autorotation
34) Forced landing
35) High-speed flight
36) Instrument flight
37) Transition night maneuvers
38) Mountainous area flight
39) Cold weather flight

(b) Gunnery

1) 30 mm running fire
2) 30 mm hover fire
3) 2.75 inches FFAR delivery - precision
4) 2.75 inches FFAR delivery - primary
5) 2.75 inches FFAR delivery - backup
6) Hellfire delivery - direct
7) Hellfire delivery - indirect
8) Hellfire delivery - single, rapid or ripple fire

(c) Terrain Flight

1) Hover in ground effects
2) Hover above ground effects
3) Low level flight
4) Contour flight
5) Nap of the earth flight
6) Mask/unmask
7) Obstacle clearance
8) Interpret terrain
9) Nap of the earth navigation
10) Pop-up maneuver
11) Nap of the earth downwind approach
12) Confined area landing
13) Confined area takeoff
14) Nap of the earth quickstop
15) Night nap of the earth operations - with visionics
16) Night Nap of the earth operations - no visionics

(d) Tactics

1) Nap of the earth formation
2) Select reconnaissance
3) Select landing zones
4) Evasive maneuvers
5) Convoy cover
6) Ground troop linkup
7) Coordinate tactical air strikes
8) Coordinate indirect fire
9) Target search
10) Target acquisition
11) Target identification
12) Standoff fire
13) Suppressive fire
14) Area fire
15) Massed fire
16) Engage air targets
17) Engage anti-aircraft systems
18) Engage armored vehicles

19) Target damage assessment
20) Handoff
21) Employ chaff and smoke
22) Tactical instrument flight
23) IR missile counter-measures
24) Radar/anti-aircraft counter-measures
25) Threat aircraft counter-measures
26) Night training (areas 1-25)

3.4.1.5 Image Quality - The final images displayed to the trainees shall each provide correct depth perception cues and dynamic fidelity to permit judgment of range, height, velocity and rate of closure. The image shall not include any discontinuities, irregularities or bleed-through of targets, nor shall it contain stray images throughout the field-of-view or visual display system range of operation. All points in the image shall maintain proper linear and motion perspective.

3.4.1.6 Tactical Area - The maneuvering area shall be composed of villages and wooded and open areas containing fields, streams, roads and lakes. Both friendly and opposing forces shall be disposed therein along with various debris evidencing the effects of battle. The area shall be 40 X 40 KM.

3.4.1.7 Training Environment - The environment shall be one of intense military activity under all weather conditions, at any time of day.

3.4.1.8 Training Maps - Maps of the training area shall be provided in the format of typical military maps.

3.4.1.9 Time Sharing - All displays shall be concurrent except as controlled by crew selection.

3.4.1.10 System Accuracies - The line of sight of the window display and visionics shall be aligned with all weapons systems and bore-sighted to the accuracy of the aircraft equipment. The visual system will maintain alignment within this accuracy for a minimum of 16 operating hours. Realignment shall be accomplished within a maximum of one hour.

3.4.1.11 Dynamic Realism - Lag between visual and motion cues shall be as specified in paragraph 3.4.1.2.1. All image motion (relative to the eyepoint) shall be smooth and continuous without discrete stepping.

3.4.1.12 Design Requirements

3.4.1.12.1 Visual System Alignment and Setup - It shall be possible to perform all required alignment procedures in a period of one hour or less, by means of standard and special test equipment supplied by the contractor.

3.4.1.12.2 Visual System Warm-Up and Stability - The visual system components and subsystems shall incorporate such circuitry, components, and compensation techniques as not to require more than 30 minutes for warm-up and stabilized operation. Stabilized operation shall permit continuous operation of the visual system for a minimum period of 16 hours, after normal alignment procedures have been accomplished, without system adjustment or realignment. Picture quality as observed in the cockpit display shall not deteriorate to a point where it fails to meet any of the performance requirements as defined in this specification at any time during the 16 hour period.

3.4.1.12.3 Compatibility with Cockpit Motion - There shall be no interference with motion system response or excursions arising from the size, weight, inertia, or shape of those parts of the visual display systems mounted on or about the motion systems and cockpits. The visual display shall permit entrance to or egress from the cockpit. All visual display system components mounted on the motion system base shall be able to withstand twice the maximum rated linear and angular motion system acceleration and jerk while performing within the visual system specification performance; that is, the television display and all optics shall remain aligned, electronic noise shall not be introduced into the video,color registration shall remain in alignment, and so forth. Maximum acceleration and jerk caused by worst-case failure of the motion system shall not result in any permanent damage to the visual system components.

3.4.1.12.4 Cleaning Provisions - All optical components shall be capable of being cleaned on-site by properly trained training device maintenance personnel without damage.

3.4.1.12.5 Radiation Shielding - Radiation shielding shall be in accordance with MIL-R-9673.

3.4.1.12.6 Light-Tight Enclosure - A light-tight enclosure shall exclude all light transmission to the cockpit from external sources and shall allow access around the fuselage.

3.4.1.12.7 Grounding - A consistent grounding system shall be employed which recognizes and provides for both personnel safety and noise immunity requirements. All chassis and conductive metal surfaces shall be referenced to the

facility power ground. Signal grounds shall not be connected between assemblies but shall be brought to a common single point ground. The single point ground will be referenced to the facility power ground. Critical signals shall be communicated between assemblies by differential transmitters and receivers.

3.4.1.12.8 Reliability and Maintainability - The visual system shall exhibit a minimum mean-time-between-failures of 50 hours. The maximum allowable repair time, at the 90% point, shall be 90 minutes. The percentage of down time due to visual system maintenance shall be no greater than 8 percent of scheduled operating time.

3.4.1.12.9 Government Furnished Equipment - The government shall furnish the pilot and copilot/gunner helmets, the aircraft AMS and the TADS pedestal and equipment, less the sensors but including the symbol generator and tape recorder unit. Also to be supplied are ortho-photographs and topographical maps of the area to be modelled in the digital data base.

3.4.1.13 Instructor Station - Controls and displays will be provided to enable the instructors to select, control and monitor visual system functions associated with all phases of training, including the following:

(a) to activate or deactivate the visual system
(b) to monitor the visual scene from any of the visionics systems except that of the DVO.
(c) to initialize the a/c as desired in the visual gaming area
(d) to modify weather conditions affecting the visual scene
(e) to set day, dusk, or night lighting conditions
(f) to control cultural lighting
(g) to monitor malfunctions in the visual systems
(h) to control and modify friendly and threat forces and fire for realistic dynamic tactics training
(i) to monitor gunnery scanning and sighting techniques at the instructor stations
(j) to replay up to the last 3 minutes of simulator performance with visual and to reset to the position before the replay
(k) to freeze and unfreeze the simulation problem and the visual scenes
(l) to monitor visual system operational readiness status

3.4.1.14 Performance Tradeoffs- Where system trade-offs are involved, the order of precedence for desired system characteristics is:

(a) Development schedule and risk
(b) Weapons accuracy
(c) Operating range
(d) Maneuvering area
(e) Resolution
(f) Cost
(g) Field of view
(h) Reliability/Maintainability
(i) Growth potential
(j) Chrominance

3.4.2 Detail Visual System Requirements

3.4.2.1 Window Display

3.4.2.1.1 Resolution - It is desired that the size of the smallest picture element (pixel) be 2.7 arc-minutes. In no case shall the pixel size be greater than 3.6 arc-minutes. The contrast of the pixel shall be at least 35% of the low spatial frequency full contrast signal. Modulation transfer function area shall not be deemphasized to achieve other performance parameters.

3.4.2.1.2 Field of View - The minimum field of view for the pilot and copilot shall be 160° horizontal by 45° vertical as shown in Figure 3.26. It is desired that the horizontal field of view for both crew members be 180°.

3.4.2.1.3 Contrast Ratio - The contrast ratio as observed by the crew shall be no less than 15:1.

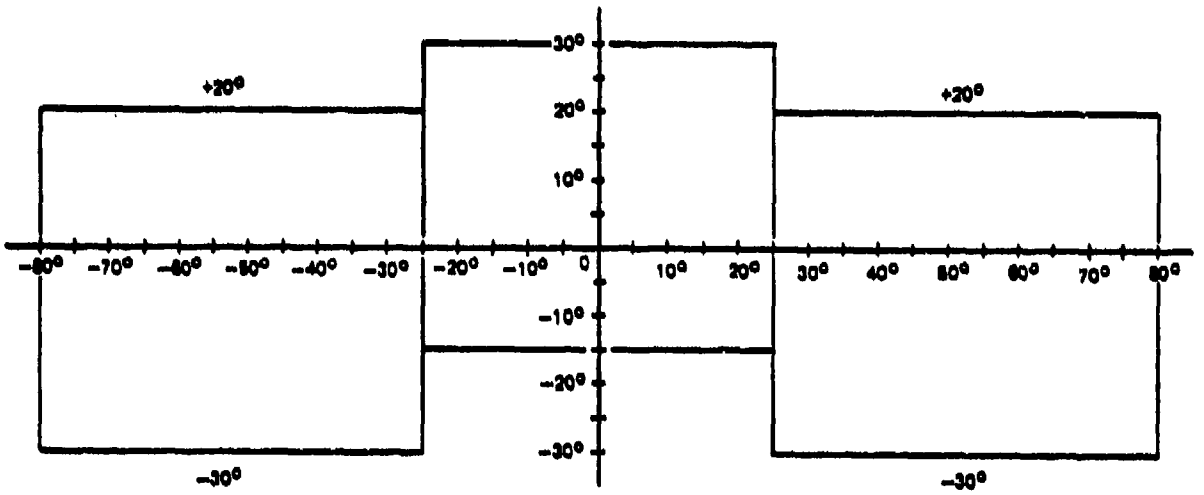
3.4.2.1.4 Brightness - It is desired that display brightness as observed by the crew be at least 12 foot-lamberts. The brightness shall not be less than 8 foot-lamberts.

3.4.2.1.5 Flicker - The display shall have no observable flicker. The TV field rate shall be 60/sec.

3.4.2.1.6 Distortion - The distortion present in all displays shall be sufficiently low to satisfy the requirements of paragraph 3.4.1.10.

3.4.2.1.7 Collimation - It is desired that the window display be collimated to provide correct eye accomodation for objects at infinity. The rays from the crew members' eyes shall converge at a distance no closer than 40 feet or -200 feet for objects at infinity.

a) PILOT



b) COPILOT GUNNER

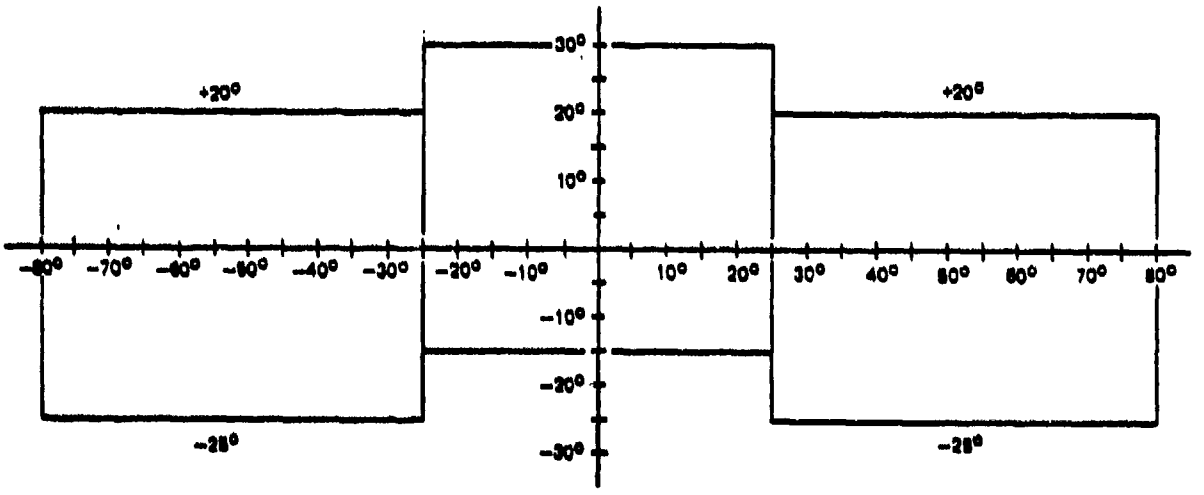


FIGURE 3.26 FIELD OF VIEW DESIGN REQUIREMENTS

3.4.2.1.8 Pupil - The pupil shall be 15 cm in diameter for both the pilot and copilot.

3.4.2.2 Visionic Displays - The visionic displays shall present forward looking infra-red, day television and night visual system simulated imagery to both the pilot and copilot/gunner on their helmet-mounted displays or to the copilot/gunner through his TADS eyepiece and monitor. In addition to the above, direct view optics imagery shall be available to the copilot/gunner through his TADS eyepiece.

3.4.2.2.1 Physical Size and Appearance - The physical size and appearance of the visionic equipment and symbol generator symbology shall appear the same as the aircraft equipment.

3.4.2.2.2 Simulation of Sensor Effects - The operating characteristics of the sensors which result in blooming, streaks, overload, etc. shall be simulated to the extent feasible.

3.4.2.2.3 Field of View - The instantaneous field of view of the FLIR, TV, and PNVS displays shall be within 10% of the flight equipment. The instantaneous field of view of the DVO shall not be less than 80% of the flight system.

3.4.2.2.4 Resolution - The displayed resolution of the FLIR, TV, and PNVS imagery, as determined by pixel size and contrast ratio, shall give the same appearance as the flight equipment. The resolution apparent in the DVO display shall be at least 350 line pairs per picture height within the central 2/3 of the FOV.

3.4.2.2.5 Image Detail - The amount of detail present in the visionic displays shall increase as decreasing fields of view are selected. The maximum detail presented shall be at the highest magnification and shall correspond to the maximum detail available through the window display. There shall be no perceptible TV line structure in the DVO display.

3.4.2.2.6 Spectral Fidelity - The spectral signature of the FLIR and TV imagery shall be as defined by the government for the various topographical features, with the goal that the simulated vegetation, vehicles, buildings, etc. appear the same as in the real world through the appropriate detectors. The direct view optic simulation shall provide color differences in the image detail. The spectral signature of the displayed topographical features will be photopic.

3.4.2.2.7 Slew - The visionic display shall blank when the instantaneous field of view is changed. The delay between the termination of slew and the appearance of video shall be no more than 250 milliseconds.

3.4.2.3 Image Generation

3.4.2.3.1 Image Content

3.4.2.3.1.1 Terrain - The terrain shall consist of a 40 km X 40 km square, representative of western Europe,based on ortho-photographs and topographical maps, supplied as GFE. This area will be composed of hilly terrain, approximately 10% village, 60% wooded, and 30% open area, the open areas to contain but not be limited to fields, roads, streams and lakes. The terrain shall contain the debris of battle to include vehicle, wooded area, and building wreckage.

3.4.2.3.1.2 Targets - The targets shall consist of a mix of both friendly and opposing forces and must be distinguishable as such. Friendly forces shall consist of a minimum of four AAH, three ASH, ten tanks and five vehicles. Opposing forces shall consist of a minimum of four Zeus 23 tanks, twenty T62 tanks, twenty T72 tanks, ten armoured vehicles and 5 HIND helicopters. Opposing forces shall have the capability of acquiring and firing on the subject AAH. Twenty of the force vehicles shall be shown in movement as appropriate to their situation and capabilities, with ground tracks, dust, smoke, debris, flashes and glint.

3.4.2.3.1.3 Digital Image Generation Equipment - The operating requirements for the AAH digital image generation hardware are based on the scene content described above, and on the need to produce imagery for both the window displays and the visionics displays.

In the case of the window displays, the requirement is for three image planes, one each for the left side, front, and right side. Viewpoints for the pilot and copilot/gunner are sufficiently close together, and the viewing requirements for the copilot/gunner are sufficiently confined to the lower ranges, that the three window displays for the copilot/gunner can be simple repetitions of the image planes presented to the pilot.

The requirement then is for 8,000 display edges in these three window image planes, either all in one window or allocated across all three in whatever proportion the instantaneous scene requires.

A display edge is defined as the boundary of a forward-facing polygon, within the field of view, except that whenever two polygons share an edge so that both endpoints coincide, that is considered only one display edge. Display edges which are on the forward-facing sides of objects (that is, the side toward the viewer, but are occulted by closer objects, and would be visible if that closer object were removed, are to be counted as part of the displayed edges.

In the case of the visionics displays, the image generation equipment shall provide four different image planes, in order to service the four displays (pilot's helmet display, copilot/gunner's helmet display, main TADS display, and CRT just below TADS). Switching equipment must be available to allow the various computed scenes to be shared among these displays as allowed in the actual aircraft equipment.

The requirement for the four visionics displays is also 8,000 edges, again to be allocated either in one display or across all four in whatever proportion is needed, with the exception that this number may be reduced by up to 15% when, and only when, there is a scene requirement to utilize a portion of the hardware capacity to assist in the production of special effects including weapon impacts, range finding operations, and the like.

The requirement in both cases (window and visionics) is for computation of edge positions on the image planes each 1/30 of a second, except that provisions must be made for the elimination of double-imaging effects caused by computation at frame rates, display at field rates, and angular motion of edges and objects across the image plane. Where necessary to eliminate these effects, computation of edges shall be made each 1/60 second.

Each of the two groups of displays (window and visionics) shall independently be supported by the capability to compute 256 intersections of edges of forward-facing polygons with each scanline. This intersection capability shall be such that it can be allocated freely among the simultaneous scanlines of the three window image planes, and among the simultaneous scanlines of the four visionics displays, such that in each case, the total shall be 256.

It shall be possible to allocate any 64 out of 262,000 color combinations to the objects in any one frame. It shall be possible to specify any one of 64 gray shade intensities to any polygon. Smooth shading of polygons within an object, to impart the appearance of roundness of the object, shall be provided for use where needed, and shall utilize not less than 255 gray shade steps in performance of the smooth shading.

The equipment shall be capable of supporting 256 object priorities, or levels of occlusion, both for the window displays and the visionics displays.

Edge smoothing, both for edges that are more nearly vertical and those that are more nearly horizontal, shall be provided to alleviate horizontal or vertical stair-stepping effects. Measures shall be provided to reduce the scintillation of small or narrow polygons as they interact with the scanline structure.

The equipment shall be capable of incorporating reduced visibility effects, including fog and haze, computed as a function of the range to the scene element.

It shall be possible for the equipment to display lights of any of the 64 colors described above, in lieu of display edges, at a substitution rate of one light per display edge.

The equipment shall be capable of displaying scenes of similar geometry but varying in color or gray shade as appropriate to the production of correlated visual and infrared scenes.

The equipment shall be capable of displaying, on each window and on each of the visionics displays, a raster of 1000 scan lines, each of 1000 picture elements, except in those cases in which actual aircraft equipment simulated contains fewer scanlines or picture elements.

The equipment shall be capable of displaying 20 moving objects in the scenes of the windows and visionics displays.

3.4.2.3.1.4 Forces Effects - The image generation shall include the capability for the following effects associated with the various forces and weapons. Vehicle motion shall result in visible ground tracks, where appropriate, indicating the path of previous vehicle location. A dust cloud will be generated, where appropriate to terrain and vehicle movement. The dust cloud will expand and dissipate in a realistic manner. Helicopter rotor down-wash shall produce dust clouds in a realistic manner with the opacity of the cloud determined by the altitude of the helicopter. Weapons effects such as glint, tracer, dust, flash, and smoke shall be generated. Glint will be selectively displayed to reveal force location at ranges where detection by the crew would be otherwise difficult or impossible. Tracers shall be selectively employed to indicate shell trajectory, accompanied by dust puffs to indicate impact with the terrain where appropriate. Flash and smoke shall be displayed to indicate detonation of ordnance in a realistic manner, appropriate to the type of ordnance and nature of impact. Smoke so generated will expand and dissipate in a realistic manner. Smoke generated by a destroyed object, such as a vehicle, shall form a plume which will vary in opacity in relation to the distance from the object.

3.4.2.3.1.5 Environmental Effects - The visual effects of environmental conditions, including but not limited to time of day, rain, mist, fog, haze, cloud, and snow shall be simulated in a realistic manner. Visibility shall be selectable in 16 discrete steps from 0.2km to infinity and shall be related to object slant range. Rain effects shall include streams which appear to emanate from a point at a selectable crab angle from the velocity vector. The angle of the streams to the horizontal shall vary according to aircraft air speed. Mist and haze shall

appear as a decrease in contrast, as a function of slant range. Visibility range shall be selectable by the instructor. Display brightness shall automatically be decreased to realistic levels for mist simulation. Snow cover shall cause a gradual white-out due to rotor down wash at low altitudes, with the opacity of the white-out varied as a function of aircraft altitude.

3.5 Computer System

The computation system shall consist of one or more digital computer(s), appropriate interface, equipment, peripheral equipment and associated software as required to comply with the functional and other requirements specified in 3.3.1 through 3.3.5.2. Output data from the computation system shall actuate displays and other equipment with a minimum of conversion or transfer devices.

3.5.1 Selection of Materials, Parts, and Processes. Only commercially available equipment currently in production and in use by other than the trainer manufacturer shall be used to satisfy the requirements of this specification, the selected computer, peripheral equipment, and maintenance diagnostics shall be the same as for other current flight simulators to be installed at Fort Rucker. The digital computer complex shall provide the computations and control of the motion systems, trainee stations, instructor stations, and other equipment as required.

3.5.2 Design. Commercially available equipment that is currently in production and use shall be selected and used to satisfy the requirements of this specification. Selection of suitable specifications and standards for procurement shall be the responsibility of the contractor.

3.5.3 Performance. The computer, interface, and peripheral equipment when installed in the trainer shall not prevent the trainer as a system from meeting all of the other requirements of this specification (i.e., EMI and the like).

3.5.4 Construction. Power failures or emergency interruptions of power to the trainer and/or computer(s) shall not result in physical or electrical damage to the computer system equipments.

3.5.5 Details of Components.

3.5.5.1 Digital Computer Complex Configuration - The digital computer complex shall provide simultaneous computation for and control of the motion system, trainee station, instructor station, visual simulation systems and other equipment as required.

a. Digital Computer System - Each digital computer system will consist of multiple central processors (CPU's). The following requirements shall be satisfied:

1. All processors (CPU's) shall be identical and completely interchangeable, or they shall all be selected from a manufacturer's family of simulator processors for upward compatibility.

2. Each processor (CPU) shall be capable of communicating with any common input/output equipment and peripheral devices without involving the other processors.

3. Provisions shall be incorporated for synchronizing the timing of each CPU and for controlling all processors with common operating controls such as start, halt, and system freeze.

4. An executive program shall be used to control the multiprocessor configuration. This program shall direct the problem flow, schedule processing events, establish priority controls, control interrupts, and the like.

b. Computer Control Panel - A computer control panel shall be provided with each computer. The panel may be located on a separate console or may be incorporated into a centralized panel located on the main rack or cabinet of the computer. Switches, indicators, and controls necessary for operation of the computer shall be located on the respective control panel. The panel shall incorporate provisions for manual insertion of instructions and data, and shall contain display indicators to enable operating and maintenance personnel to monitor the operation of the computer. The operator shall have the ability to control the computer from a seated position with provision for a work top area.

c. Register information display and insertion - Display indicators shall be provided to permit selection and visual examination of the content of any memory address or program-accessible register. Hardware switches and associated controls shall be provided to permit insertion of information in any memory address or program-accessible register.

d. Halting provisions - Means shall be provided to halt the computer at any preselected program step.

e. Single-step provisions - Single instruction advance and single clock pulse advance will be available for stepping the program in the computer.

f. Running time meter - A running time meter shall be installed in each computer and shall indicate the elapsed computer "ON" time. The meter shall display at least five digits in increments of 0.1 hour.

g. Power fail-safe provisions - A power fail-safe interrupt provision shall be included to enable restart of simulation within 5 minutes after return of power to the CPU's.

h. Real-time clock - A program addressable real-time clock integral to each computer shall be provided with program control of the generation of necessary cycle timing intervals.

i. Computer I/O capability - The I/O system of the computer shall provide the following capabilities:

1. Capability to service assigned blocks of data to and from the I/O channels and high speed magnetic core memory without restricting the operation of the arithmetic unit except for any initial set-up and memory access priority delays (e.g., a direct memory access (DMA) capability through the medium of memory ports in conjunction with an I/O processor).

2. Capability to communicate directly with all interface equipment.

3. Capability to input or output to and from one or more units of peripheral equipment while continuing operation in the real-time simulation and processing modes.

4. Capability to provide, under program control, interrupt lines by which the computer can be interrupted by external discrete controls, devices, and/or another computer.

j. Memory requirements - The digital computers shall be furnished with sufficient high speed random access memory to store the total system simulation, control programs, and executive programs and all constants, real-time data operands, and intermediate results.

k. Computer system spare capacity - The computer system shall provide spare memory and processing capacity as specified below.

1. Spare memory capacity - not more than 50 percent of the memory of each computer shall be used to meet the total real-time program and data storage requirements.

2. Spare processing capacity - the total processing time required in the logical worst case path during any program iteration or solution cycle shall not exceed 50 percent of the time available for that cycle. Also, during any one second iterval the time required to process all real-time programs shall not exceed 500 milliseconds.

3. Disc spare capacity - not more than 50 percent of the disc unit shall be utilized.

l. Peripheral equipment - Computer peripheral equipment shall be provided to support each digital computer system in meeting the requirements of this specification. The following peripheral devices shall be provided with the characteristics indicated:

1. One CRT or TTY with alphanumeric keyboard.

2. CRT display system including a keyboard in teletype format.

3. A disc pack drive and controller system capable of accommodating all required spare and all real-time simulation programs, data maintenance programs, test and diagnostic programs, and utility and related programs. The use of real-time overlaying techniques from disc storage shall be limited to data only. It shall not be used for reducing resident real-time program storage requirements for computer main memory.

4. A standard 80-column card reader capable of operating at 300 cards per minute read speed.

5. A versatec 1100A printer/plotter or equivalent.

3.5.5.2 Computer System Software Requirements - All programs required to operate and support Device 2B4Ø shall be designed and documented in accordance with good commercial documentation practice.

a. Program language requirements - FORTRAN IV with any available extensions shall be used.

b. Program requirements - The programs supplied with Device 2B4Ø shall include, but not be limited to the following:

1. Real-time simulation, control and processing programs - The real-time simulation programs shall perform all simulation, control, and processing functions specified herein.

2. Off-line function data generation program - For dynamic vehicle simulation, vehicle function data may be incorporated into the main trainer programs. In the event stored function data are derived by an off-line computer program, this program shall be included in the program package.

3. Utility programs - Trainer computer system utility programs consisting of, but not limited to, assembler, loader, data conversion, memory dump, printout, and FORTRAN compiler shall be provided.

4. System verification programs - Programs shall be provided to verify the simulation and display processing programs. These programs shall provide a means of checking and verifying the overall correctness of the main simulator control and other processing programs independently of the trainer stations and the computer interface equipment.

5. Maintenance and test programs - The maintenance and test programs shall test the operation of both the computers and peripheral equipment and the trainer simulation equipment. Maintenance programs shall include but not be limited to the following:

a) System daily readiness check program - A daily readiness check program(s) shall be designed to enable operating personnel to determine visually that the trainer is ready for operation. The checks shall utilize the normal iteration rate of the various programs. Provisions shall be made for stepping through the program or portions thereof incrementally to verify the desired output at each step. The operator shall have the option of either proceeding, after he has noted discrepancies, or stepping the computers to determine the type and nature of the failure.

b) Real-time interface equipment diagnostic program - Program(s) will enable on-line program diagnosis of the training device interface equipment malfunctions. These program(s) shall be automatic and require a minimum of operator effort. They shall provide hard-copy printout of the nature of the malfunction and of the test(s) results.

c) Discrete input and output check-out programs - This program shall provide for checking the proper functioning of the discrete input and output channels of the device in a closed loop manner. All disconnection and reconnection shall be accomplished under program control or by a patchboard-type device. The operator shall also visually verify the correct status of discrete indicators and determine the proper operation of manual switches which interact with this test program. The program upon detecting a malfunction shall indicate the failing channel to the operator via on-line hard-copy printout.

d) Analog input and output checkout program - Programs will test all analog channels and devices through their full range of operation. All channels not functioning within design limits shall be indicated to the operator via hard-copy printout. A dynamic test of the analog output channels shall also be provided.

e) Computer diagnostic programs - Only commercially available diagnostic programs for the selected computers shall be used. The programs shall check the operation of the arithmetic unit, control unit, I/O unit, and memory unit.

3.6 Motion system - A motion system in accordance with the requirements stated herein shall be provided. The motion system shall provide a minimum of six degrees of freedom consisting of pitch, roll, yaw, heave, and sway (lateral) and longitudinal. Corrective correlation of cockpit motion and visual cues is essential.

3.6.1 Degree of simulation - The sensations of motion shall be representative of sensations experienced in the operational design basis aircraft resulting from changes in attitude and/or flight path. Representative motion caused by the following aircraft conditions shall be provided: buffets, blade stall, blade imbalance, damper failure, blades out of track, skids, slips, banks, turns, hovering, climbs, dives, acceleration and deceleration, transition into and out of stable flight, vibrations, oscillations, touchdown impact and control-induced changes in the exterior configuration of the aircraft, atmospheric effects, and sling load dynamics.

3.6.2 Motion system computations - The physical movement of the motion system shall be determined by computations based upon six degrees of aircraft freedom and movement along or about all axes of the motion system and shall be correlated with the motion of the simulated aircraft. All aircraft stability derivatives shall be accounted for in a manner such that aircraft movement in any degree of freedom shall influence movement along or about every axis of the motion system. The motion system shall respond to aircraft center-of-gravity or center of pressure movements, including: fuel depletion, cargo loading, and normal aerodynamic effects. The acceleration of the trainee station in any degree of freedom shall not exceed the aircraft acceleration experienced under similar flight and configuration conditions of the operational aircraft simulated.

3.6.3 Operational performance - The motion system design shall emphasize onset of accelerations to provide proprioceptive cues to the trainee. Following the initial transient force, the cockpit shall return imperceptibly to normal straight and level flight attitude, except that the cockpit shall maintain an appropriate amount of the commanded pitch attitude. The aircraft instrument indications and visual display presentation when in use shall reflect the simulated flight condition regardless of cockpit attitude. There shall be no noticeable time error between instrument response, and trainee station movement except normal lag associated with a given aircraft component.

3.6.4 Performance limitations - The motion system driving inputs from the computer shall be so mechanized as to optimize the onset cues to the trainee. This shall be done in a manner such that actual cockpit motions may within physical limitations and correctly track the frequency of the motions but not necessarily the amplitude. The envelope of motion system movement during training shall be such that the full displacement range

(bottom-to-top, side-to-side, and the like) is utilized to the maximum extent.

3.6.5 Onset of acceleration cues - The onset of acceleration cues provided shall be determined by the equations of motion of the aircraft.

3.6.6 Payload weight - Performance requirements shall be met at the normal operating weight (consisting of trainee station, instructor station, visual system, and four personnel) plus one thousand (1000) pounds.

3.6.7 Worst-case maneuvers - The motion system shall be sized to perform the simulated vehicle worst-case maneuvers in the heave direction of 0.25g sinusoidal at 1.0 Hertz for a continuous duty cycle.

3.6.8 Excursions, velocities and accelerations - The motion system shall perform to the criteria shown in Table 1. The displacement requirements of Table I are nonsimultaneous requirements; therefore, the motion system must satisfy only one set of requirements (case) at a time. The excursion envelope about the neutral operating position shall allow simultaneous movement equal to a minimum of 20 percent of the above requirement in any four degrees of freedom combination.

3.6.9 Frequency response - The closed-loop performance of the motion systems shall comply with the following:

Frequency Range (Hertz)	Maximum Phase Shift (Degrees)	Motion Platform Position (maximum Decibels)
0.1 - 0.5	20°	± 1 dB
0.5 - 1.0	60°	± 2 dB
1.0 - 2.0	110°	+ 2 dB - 4 dB
2.0 - 5.0	-	+ 2 dB - 10 dB

The above criteria apply to each degree of freedom. Structural or hydraulic resonance shall not occur from 0 to 5 Hertz. Design provisions shall be incorporated to avoid activation of resonant frequencies above 5 Hertz by the simulation program.

3.6.9.1 Static accuracy - Static error between actual and commanded platform position shall be less than 1.0 percent of full scale.

TABLE 3.1

Minimum Performance Requirements*

Case	Axis	Excursion	Peak Acceleration	Peak Velocity
1	Vertical	64 inches total ± 32 inches	± 0.8g	24 $\frac{\text{incnes}}{\text{sec}}$
2	Lateral	80 inches total ± 40 inches	± 0.6g	24 $\frac{\text{inches}}{\text{sec}}$
3	Longitudinal	90 inches total ± 45 inches	± 0.5g	24 $\frac{\text{inches}}{\text{sec}}$
4	Pitch	50 degrees total ± 25 degrees	±50 $\frac{\text{degrees}}{\text{sec}^2}$	20 $\frac{\text{degrees}}{\text{sec}}$
5	Roll	44 degrees total ± 22 degrees	±50 $\frac{\text{degrees}}{\text{sec}^2}$	20 $\frac{\text{degrees}}{\text{sec}}$
6	Yaw	56 degrees total ± 28 degrees	±50 $\frac{\text{degrees}}{\text{sec}^2}$	20 $\frac{\text{degrees}}{\text{sec}}$

* Based upon sinusoidal movement throughout the total excursion for each case, continuous duty cycle.

3.6.10 Smoothness - The motion system shall operate without hunting and shall not snub against cushion stops during normal operation. The actuator system shall raise the trainer in an approximately level attitude to the initial operational position. Oscillations of the trainee station caused by motion system instability shall not occur. Oscillations of the trainee tation or any of its components as a result of structural, hydraulic, or electrical resonance shall not occur, unless such movement is demanded by the equations of motion of the design basis aircraft.

3.6.11 Rough air buffet - The effects of rough air and buffeting shall be simulated. Appropriate operation of the trainer controls shall result in realistic correction of the rough air effects. The rough air cycle shall be so designed that repeatability will occur only after completion of a cycle pattern of at least five minutes in duration. The intensity and direction of the trainee station motion shall be a function of the rough air level, the aerodynamic configuration of the aircraft, and pilot induced maneuvers, if any, at any instant. At any time during the rough air cycle, it shall be possible using the CRT and associated controls at the instructor station, to discontinue the rough air buffet simulation or change its amplitude. Physical motion of the trainee station shall be provided in all affected degrees of freedom while simulating rough air and shall be coordinated with instrument indications and with visual display scenery. Both horizontal and vertical rough air effects shall be provided.

3.6.12 Hydraulic and electro-mechanical design - Hydraulic and electro-mechanical design shall comply with the following:

(a) The design shall incorporate provisions for maintenance operations. All maintenance equipment including jacks and jack supports shall be provided.

(b) Water-cooled heat exchangers shall be designed for hydraulic fluid cooling with a maximum inlet water temperature of 85°F

(c) Breakaway friction of each ram shall be minimized so that for each ram assembly the peak to peak friction acceleration transient shall be less than 0.03g, for an input signal of 10 percent of maximum range at a frequency of 0.5 Hertz

(d) Hydraulic fluid shall conform to Naval Weapons Specification XWS-6788 (e.g., Brayco 745). Hydraulic fluid temperature, pressure, and level shall be monitored and equipped with sensor warning devices. Exceeded safety parameters shall automatically activate shut down of the hydraulic systems.

3.6.13 Motion and control loading system operation and controls - The hydraulic systems shall operate as follows:

(a) Control loading systems shall utilize an independent hydraulic pump from those used for the motion systems. However, the control loading systems shall be capable of being powered by either motion system's hydraulic pumps

(b) The motion systems and control loading pumps shall be remotely located in a separate room

(c) Spray shields and drip pans shall be provided to prevent drainage to trainer components

(d) A key-operated switch shall be provided to energize electrical power to the motion system

(e) Separate power shall be supplied to hydraulic pumps to minimize electrical interference.

3.6.14 Maintenance controls - A maintenance control panel shall be provided and located within view of each motion system. The maintenance control panel shall provide lighted indicators for hydraulic system status, pump controls, manual controls, a system control switch for "maintenance" and "normal" operation, and an emergency stop switch.

3.6.15 Safety provisions - The ingress/egress ramp, doors, and steps shall be covered with non-skid material and provided with safety interlocks to automatically deactivate motion system hydraulics when interlocks are broken. Interlocks shall also be provided to prevent operation of the motion system during maintenance operations. The motion system floor and platform shall be provided with railings commensurate with ingress/egress requirements. A red warning light shall be provided at the motion base when the motion hydraulics are activated. The cockpit access ramp or stairway shall be fail-safe in the event of facility power failures.

4. QUALITY ASSURANCE PROVISIONS

4.1 General quality assurance provisions.- Unless otherwise specified herein, quality assurance provisions shall be in accordance with MIL-T-23991 and MIL-Q-9858. The quality assurance program shall ensure quality throughout all areas of the specification requirements, including design, development, fabrication, processing, assembly, inspection, test, maintenance, preparation for delivery, shipping, storage, and site installation. The contractor's Quality Assurance Program shall be planned and utilized in a manner to effectively support the contractor's reliability and maintainability programs.

4.2 Responsibility for inspection.- Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the supplier may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to the prescribed requirements.

4.2.1 Test conditions.- All tests shall be conducted under the following conditions.

4.2.1.1 Signal outputs.- Servo, integrator, and signal outputs shall be set to insure proper test conditions.

4.2.1.2 Temperature.- Unless otherwise specified, tests shall be made at prevailing room temperature between 60° F and 80° F.

4.2.1.3 Test equipment and instrumentation.- Test equipment shall include a suitable electronic or mechanical control force and displacement measurement device, a timing device, a multichannel recorder, X-Y recorder, meters, and oscilloscopes. A low-frequency sine wave generator, 0.01 to 10 Hz, and a means for introducing impluse disturbances of surface deflections shall also be included. Calibration charts and conversion data shall be available during the tests.

4.2.1.4 Alignment.- The trainer shall be aligned by the trainer contractor prior to the initiation of the test program.

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4.2.1.4.1 Changes during testing. - All changes made in alignment, programming, and adjustments during the testing program shall be recorded. Any test conducted prior to such adjustments shall be repeated unless it can be conclusively proven that such adjustments have not invalidated the related test data.

4.2.1.4.2 Changes after testing. - All modifications or changes in design determined necessary as the result of a test shall be recorded. All tests run prior to such modifications shall be repeated unless it can be conclusively proven that such modifications or changes in design have not invalidated the related test data.

4.2.2 Test methods. - Tests shall be conducted in accordance with the Government-approved Trainer Test Procedures and Results Report which shall be prepared by the trainer contractor in accordance with the contract schedule. The Trainer Test Procedures and Results Report shall contain tests to verify each requirement of each paragraph of this specification. The Government reserves the right to conduct other tests deemed necessary during or as a result of Army pilot evaluation.

4.3 Facilities. - Facilities shall be in accordance with MIL-T-23991 and/or MIL-Q-9858.

4.4 Classification of inspections. Inspections to be performed are classified as follows:

(a) In-process inspection

(b) Quality conformance inspection.

4.4.1 In-process inspection. - The in-process inspection of MIL-T-23991 shall include all of the following items:

(a) Materials

(b) Parts (standard/nonstandard)

(c) Processes

(d) Interchangeability

(e) Safety

(f) Protection of parts

(g) Cooling

(h) Human factors

(i) Mechanical design

(j) Electrical and electronic design

(k) Reliability

(l) Transportability

(m) Maintainability

(n) Electromagnetic interference suppression

(o) Color

(p) Finish (corrosion protection and treatment)

(q) Nameplates and product markings

(r) Workmanship

(s) Wire making.

4.4.2 Quality conformance inspection. - Quality conformance inspection shall be in accordance with the approved Trainer Test Procedures and Results Report of the contract and shall consist of the following examinations and tests:

4.4.2.1 Examinations. - Examinations shall be in accordance with MIL-T-23991.

4.4.2.2 Tests. - The trainer shall be subjected to the following tests:

(a) Functional

(b) Trainer operation

(c) Structural

(d) Electrical

(e) Grounding and grounding systems

(f) Human factors engineering compliance

(g) Reliability

(h) Environmental

(i) Electromagnetic interference suppression

(j) Electron-tube shield electrical contact.

4.4.2.2.1 Functional tests. - Functional tests shall be performed to demonstrate and substantiate the performance of each functional operation of the trainer. The trainer shall be capable of meeting functional tests without alignment or adjustment of controls, other than the accessible controls employed for normal trainer operation. No repairs or adjustments shall be permitted during the conduct of functional tests. If any repairs or adjustments are required, the test in question, as well as any other tests whose results may be affected thereby, shall be repeated after repairs or adjustments have been made. Functional tests shall include but not be limited to the tests of 4.4.2.2.1.1 through 4.4.2.2.1.5.5(c).

4.4.2.2.1.1. Flight tests. - The following listing represents major areas in which flight tests will be performed to demonstrate compliance with the requirements of this specification:

(a) Static stability

(b) Dynamic stability

(c) Controllability

(d) Maneuverability

(e) Powerplant performance

(f) Hover/level flight

(g) Climbs/descents

(h) Takeoffs/landings

(i) V-n envelope

(j) In-flight malfunctions

(k) Weight and balance changes

(l) Typical mission

4.4.2.2.1.2 General tests. - The following listing represents major areas in which general tests will be performed to demonstrate compliance with the requirements of this specification:

(a) Aircraft systems

(b) Powerplant systems

(c) Communications/navigation systems

(d) Flight controls - friction and breakout forces

(e) Flight control/surface relationships

(f) Surface facilities

(g) Media effects

(h) Procedures

(i) Malfunctions

(j) Crash

(k) Instruments

(l) Sounds

(m) Instructor station controls and displays

(n) Trainee station problem control

4.4.2.2.1.3 Computer system software tests. - Computer system software tests shall be performed to demonstrate and substantiate the ability to meet the total software program requirements of this specification.

4.4.2.2.1.3.1 Real-time program debugging and verification. - Program debugging techniques which necessitate single-step, operator-controlled program operation shall be kept to a minimum. Initial verification of the trainer programs shall be achieved by processing through a contractor-designed and provided verification program, utilizing the basic trainer processors. Test-case data which fully test the main program(s) shall be divided into logical units for use in debugging procedures and isolation of error sources. Partial acceptance of the trainer and programs shall be based on computer runs made with data derived to meet the requirements of this paragraph.

4.4.2.2.1.3.2 Cycle time measurement program. - The contractor shall design and code programs in accordance with SECNAVINST 3560.1, which will determine the time actually required to execute the operational programs. Measurements provided by the programs shall include the following items of data:

(a) The worst-case time required for any iteration or solution cycle during the execution of the real-time program. Time data per cycle shall be accumulated over a 15-minute period to assure the achievement of the worst-case path condition. Time data shall be accumulated in total milliseconds remaining in each cycle. (Cycle time for this specification is 33.333 milliseconds.)

(b) Total time required for execution of the worst-case program condition during each second of operation. Time data per second shall be accumulated over a 15-minute period to assure the achievement of the worst-case condition per second. Time data shall be accumulated in total milliseconds remaining in each second.

4.4.2.2.1.3.3 Program acceptance criteria. - The acceptance of software programs shall be based on demonstrated ability to meet the total program requirements of this specification in accordance with the test plan and test procedures required by SECNAVINST 3560.1. Computer system software tests shall be conducted prior to conducting simulator functional tests.

4.4.2.2.1.4 Motion system tests. - Tests shall be conducted to verify that the motion system meets the requirements of this specification.

4.4.2.2.1.4.1 Displacement tests. - The displacement of the motion system in each degree of freedom shall be tested as follows:

(a) A sine-wave generator (test equipment) shall provide a command signal to any one displacement mode of the motion system.

(b) The amplitude of the signal shall be increased from zero until the limits of motion system displacement are reached.

(c) At any amplitude setting, the angular phase lag between the command signal and the motion system displacement shall meet the frequency response of this specification. Phase lag and gain decrease shall be recorded for frequencies from 0.01 Hz to 5.0Hz for input amplitudes of one percent, five percent, 10 percent, 20 percent, and 40 percent of the maximum input signal.

4.4.2.2.1.4.2 Acceleration tests. - The verification of the requirement of excursions, velocities and accelerations of this specification may be demonstrated using a dummy load.

4.4.2.2.1.4.3 Smoothness tests. - Multichannel recordings of actuator displacement and velocity versus time shall be made for each motion system actuator to demonstrate compliance with the frequency response, and hydraulic and electro-mechanical design requirements of this specification.

4.4.2.2.1.4.4 Additional tests. - Additional tests shall include recordings of theoretical (computed) aircraft displacements versus time. It shall be possible to record motion system displacement in all degrees of freedom simultaneously on a multichannel recorder. Recordings shall be made for input signals of (1) a one volt increasing step function followed in 1/2 second by a one volt decreasing step function; and (2) a one volt increasing step function. The following control inputs shall be tested:

(a) Lateral left and right cyclic inputs

(b) Longitudinal fore and aft cyclic inputs

(c) Left and right pedal inputs

(d) Collective decrease from normal flight position. (In this case, the direction of the step function shall be reversed.)

The computed aircraft displacements shall demonstrate compliance with the approved data. The motion system displacements shall, within the limitations of the motion system, correspond to the aircraft displacements for all conditions of vertical flight, transition, horizontal flight, and for all wind and gust loadings imposed. In the case of a hover, when the simulated aircraft is flown within the displacement range(s) of the motion system, there shall be a one-to-one correspondence between the simulated aircraft displacement and the motion system displacement. All equipment necessary to conduct the tests shall be furnished by the contractor.

4.4.2.2.1.5 Visual system tests. - The following tests shall be performed on the visual system both in-plant and on-site before final device acceptance to verify that all specification requirements have been met:

4.4.2.2.1.5.1 Systems integration tests. - Systems integration tests shall be performed by having two qualified Army pilots perform successfully all of the following training tasks:

(a) Basic powered flight maneuvers

(b) Ground (wheeled) taxi

(c) Takeoff to a hover

(d) Hover (in and out of ground effect)

(e) Takeoff from ground or hover

(f) Approach to hover or ground

(g) Landing from a hover

(h) Running landing (single engine)

(i) Landing roll out

(j) Standard autorotation to the ground

(k) Missed approach and go around

(l) Confined area approach and landing

(m) Pinnacle operation

(n) Tactical terrain flight

(o) Cross country flight (40 to 60 nautical miles)

(p) Instrument approach and breakout

(q) Formation flying

4.4.2.2.1.5.2 Flight/Visual interface tests. - Tests shall be performed to verify that the flight/visual interface requirements are met.

4.4.2.2.1.5.3 CGI visual system tests. -

(a) Resolution - A 100 percent positive contrast U.S. Air Force 1951 resolution test chart, or its equivalent, shall be modeled and display at a simulated distance of 20 feet to verify compliance with the resolution requirements of this specification.

(b) Contrast ratio. - A shot photometer shall be utilized to verify compliance with the contrast requirements of this specification.

(c) Field-of-view. - A theodolite shall be utilized to verify compliance with the field of view requirements of this specification.

(d) Luminance - A spot photometer shall be utilized to verify compliance with the luminance requirements of this specification.

(e) Geometric distortion - Rectangular surfaces and rectangular point light matrices shall be programmed for display. The rectangles shall be centered in the display field-of-view and shall be of a size to present rectangles at the final display whose sides are 80, 50, and 30 percent of the maximum instantaneous field-of-view dimensions. A rectangular template shall be prepared for use at the display to verify compliance with the geometric distortion requirements of this specification.

4.4.2.2.1.5.4 Infinity display optical tests. - The following tests shall apply to the CGI infinity display spherical mirrors:

(a) Radius tolerance - A 0.5-inch diameter circular stop shall be utilized to verify compliance with the radius tolerance requirements of this specification. The stop shall be located normal to and displayed orthogonally from the mirror center of curvature by 1.0 inch to produce a blur circle reflected from the entire area of the mirror required to achieve the specified field-of-view. The maximum blur circle dimension composing the image of this stop, on the opposite side of the center of curvature shall be less than 1.2 times the circular stop diameter.

(b) Uniformity of curvature - A ring spherometer with 4 ± 1 inch ring diameter capable of measuring the sagitta to .0004 inches shall be utilized to verify compliance with the uniformity of curvature requirements of this specification.

(c) Smoothness of surface - An edge target (i.e., 3 x 10-inch white cardboard with a 1/2-inch black center stripe having sharp edges) shall be used to verify compliance with the smoothness of surface requirements of this specification. Anywhere on the focal surface of the mirror, the reflex image of the edge target, as seen by an observer at the approximate center of curvature, shall not reveal any waviness (as caused by surface ripples) or feathery raggedness (as caused by "orange peel" of the mirror surface), or any other irregularity (caused by other, similar surface defects) to an unaided eye having normal 20/20 vision. The test shall be conducted with 50 ± 5 foot-Lamberts illumination on the target with less than 10 foot-Lamberts ambient illumination.

4.4.2.2.2 Trainer operation tests. - The trainer shall be tested to determine the suitability of controls and control circuits for satisfactory mechanical and electrical operation. The trainer shall be subjected to operation tests in normal room temperature, 68 degrees F ± 5 degrees, of not less than 6 hours duration to insure qualitatively the proper functioning of the device including all operating controls, supply line voltage, ranges and frequencies, conditions of extreme limits, and conformance to applicable safety requirements. During the operation period, not less than 12 complete cycles of performance shall be accomplished by the contractor in the

presence of the Government inspector to demonstrate compliance with the requirements of this specification. All components, fixtures, controls, and mechanisms shall be moved through their maximum normal displacements and shall exhibit no malfunctioning or objectionable rough operation, vibration, or irregular movements.

4.4.2.2.3 Structural tests. - The contractor shall subject typical assemblies, such as amplifiers, servos, and electronic chassis, to one or more of the following tests as necessary to determine compliance with the specification strength requirements. Striking of adjacent items, large excursion of any item or loosening of fasteners during these tests shall make the design unacceptable. Actual assemblies and methods of attachment of the actual assembly up to the point of rigid mounting to rigid structure shall be used. For this purpose, cabinet shock mounts shall be considered as rigid mounting. Where items are mounted with marginal spacing the test assembly shall include parts, assemblies, components, mountings, and spacings representing the most critical conditions. The contractor shall submit a list of assemblies to be tested for review and approval to the Procuring Contracting Officer.

4.4.2.2.3.1 Vibration tests. - Test specimens shall be subjected to approximately sinusoidal vibration in three mutually perpendicular directions parallel to the edges of the specimen in accordance with the following table:

Type of Test	Amplitude	Frequencies	Duration
Exploratory	0.02 inch	5 thru 33 Hz	As required to determine resonant frequencies
Survey	0.06 inch	5 thru 33 Hz in 1 Hz steps	Three minutes at each step frequency
Endurance	0.06 inch	Each resonant frequence or, in case of no resonance at 23 Hz	Two hours. In case of multiple frequencies divide time equally.

4.4.2.2.3.2 Shock tests. - Items which are normally subjected to bench servicing, such as amplifiers, shall be subject to the following bench handling tests. The item, in its normal servicing configuration, shall be placed, as for servicing, on a solid 2-inch fir bench top or equivalent.

(a) The item shall be tilted up through an angle of 30 degrees using one edge of the item as a pivot, and dropped to its original position

(b) Repeat (a) with the item placed on other faces, until it has been dropped for a total of 4 times on each face on which it could be placed during servicing.

4.4.2.2.4 Electrical tests. - In addition to the electrical tests of MIL-T-23991, the trainer shall also be tested for maximum power demand.

4.4.2.2.5 Grounding and grounding systems tests. - In addition to the grounding and grounding systems tests of MIL-T-23991, tests shall be conducted to verify the requirements of this specification.

4.4.2.2.6 Human factors engineering compliance tests. - Human factors engineering compliance tests shall be in accordance with MIL-T-23991 including verification of the lighting and acoustical noise requirements of this specification.

4.4.2.2.7 Reliability tests. - Reliability tests shall be as required for the reliability demonstration of 4.7.1.

4.4.2.2.8 Environmental tests. - Environmental tests shall be conducted as follows:

(a) Temperature measuring shall be performed during the conducting of trainer operation tests with all covers in place and doors closed and at the specified temperature. Temperature measuring instruments shall be placed at critical points throughout the trainer, covering suspected high-temperature areas. Data shall be recorded at least once during each hour of trainer operation. Data thus obtained shall indicate location of the measuring instrument, the temperature (^{o}F) at the measured point, and the ambient temperature (^{o}F)

(b) Maximum heat generation of the trainer

(c) Equipment cooling requirements.

4.4.2.2.9 Electromagnetic interference suppression tests. - The trainer motion system shall be tested to the RS03 requirements of MIL-STD-461 between the frequency range of 10 MHz to 400 MHz at a level of 1 volt per meter. Details of the test procedure to be used shall be submitted with the Electromagnetic Interference Control Plan. In addition, crosstalk and signal-to-noise ratio tests shall be performed to verify that the requirements of MIL-C-29025 have been met.

4.4.2.2.10 Electron-tube shield electrical contact. - The contact resistance of electron-tube shields shall be tested in accordance with MIL-T-23091.

4.5 Extent of testing and test conditions. - The extent of testing and test conditions required to determine quality assurance for Device 2B40 shall be as specified in 4.2.1, 4.2.2, 4.4, and 4.7, including subparagraphs thereto.

4.6 Material to accompany training devices. - Material to accompany training devices shall be in accordance with MIL-T-23091.

4.7 Demonstrations. -

4.7.1 Reliability demonstration. - An in-plant reliability demonstration shall be conducted in accordance with the requirements of MIL-STD-781 and the Government-approved Reliability Test and Demonstration Plan to be provided by the contractor under the provisions of the contract. The purpose of the demonstration will be to ascertain whether or not Device 2B40 performs in accordance with the quantitative MTBF requirements of this specification. The following additional criteria shall apply:

(a) Test Plan XXI, Test Level A-1, of MIL-STD-781 shall be utilized to demonstrate θ_0 and θ_1.

(b) Failure criteria shall be in accordance with the following:

(1) When a failure is due to: adjustment (maintenance or installation), design defect, manufacturing defect, any other part defect, workmanship, misapplication, part wear or unknown reasons, the failure shall be categorized as relevant.

(2) When the failure is due to: accidental damage, adjustment (operator), drawing error, failure of another part (secondary failure), installation error, operator error, scheduled replacement, or failure of test equipment or facility, the failure shall be categorized as nonrelevant. Nonrelevant failures are not counted for determining reliability, but are recorded in order that corrective action may be taken as required.

(3) When two (2) or more failures of the same part occur in identical or equivalent application, whose combined failure rate exceeds that predicted, the failure(s) shall be categorized as a pattern failure. When two (2) or more secondary failures of the same part occur, whose combined failure rate exceeds that predicted, and which are due to

more than one primary failure, the secondary failure shall be categorized as a relevant pattern failure.

(c) The duty cycle to be maintained throughout the demonstration shall be typical of normally scheduled training operations, with all operating modes of the trainer being exercised.

4.7.2 Maintainability demonstration. - A maintainability demonstration shall be conducted in accordance with the maintainability requirements of MIL-STD-471, and the contractor-prepared, Government-approved demonstration plan. The purpose of the demonstration will be to ascertain whether or not Device 2B40 performs in accordance with the quantitative MTBF requirements of this specification. The following additional criteria shall apply:

(a) Test Method 9 of MIL-STD-471 shall be utilized to demonstrate the specified MTTR

(b) The maintainability task to be demonstrated shall be selected from an approved list of 50 simulated tasks submitted by the contractor in accordance with MIL-STD-471, Appendix A.

5. PREPARATION FOR DELIVERY

5.1 Preparation for delivery. - The trainer shall be packaged, packed, and marked in a manner that will insure acceptance by common carrier and safe delivery at destination.

6. NOTES

6.1 Intended use. - The principal use for Device 2B40 will be for pilot transition training, integrated crew training, and for the maintenance of contact and instrument flight proficiency in the AAH, with emphasis on combat flying skills such as nap-of-the-earth flight, and target engagement and ordinance delivery. These applications will include concern for both techniques and procedural skills. The trainees using the device will be previously rated Army helicopter pilots. Trainees will be able to perform all normal and emergency instrument and visual flight maneuvers within the constraints of the visual system. The trainer will also be used for the training of instructor pilots.